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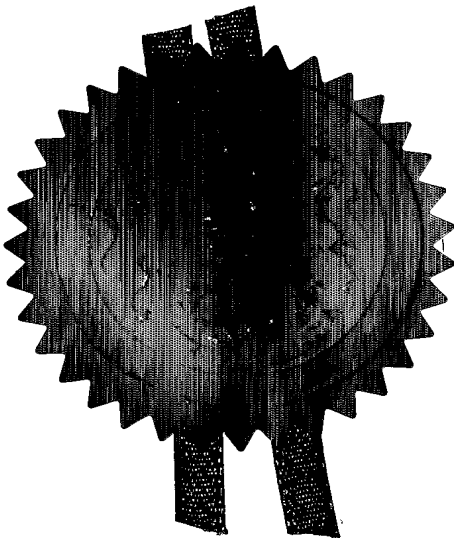
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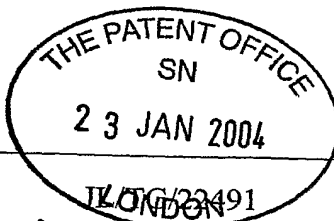


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Patents ADP number (*if you know it*)

If the applicant is a corporate body, give the country/state of its incorporation

7219991001

4. Title of the invention

A DEVICE FOR PICKING OLIVES

5. Name of your agent (*if you have one*)

A A THORNTON & CO

"Address for service" in the United Kingdom to which all correspondence should be sent (*including the postcode*)

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Date

23 January 2004

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A DEVICE FOR PICKING OLIVES

TECHNICAL FIELD

The present invention relates to devices for picking fruit and in particular it can be used for olive picking.

BACKGROUND ART

The invention has been designed for picking olives, so the discussion of the background art and of the specific embodiments is limited to this particular application of the invention.

A known method for picking olives and other fruit is manual labour, whereby fruit is removed from trees by hand picking. This is both time-consuming and costly.

Also known are mechanical shaking devices which apply mechanical vibrations directly to the trunk or branches of an olive tree to remove olives, which may be gathered in a net placed on the ground, or by a vertical net having the shape of an upside down cone surrounding the tree trunk. The mechanical shaking method tends to damage the trees and leads to the unwanted removal of leaves and small branches. Some such methods employ a shaker head attachable to an olive tree-trunk or branch. The shaker head can oscillate with a power of up to 40 horse power and is driven by a hydraulic motor which imparts rotary motion to an eccentric mass. The eccentric mass generally comprises a rotatable mass with a high inertia which is difficult to control and slow. Response times for these machines are also slow. The consequences of component failure may also be dangerous in such machines, especially if the eccentric mass is rotating at the top end of its speed range.

Some machines provide for adjustability of the speed of the rotating mass. Such oscillating machines generally apply very complicated oscillations of a single dominant frequency or over a very narrow width of dominant frequencies with little regard for the effect on the tree and its roots, and thus the trees are prone to damage often including substantial removal of leaves and/or twigs of the tree. The construction of these oscillating machines generally involves the shaker head being suspended from a carrying frame by means of chains or springs. Another disadvantage of these methods is that only the ripest olives are removed from the tree. The not so ripe olives, which may constitute as much as 40% - 50% of the potential crop, remain attached to the plant. To recover as many of these olives as possible the plant is subjected to further mechanical shaking after one or several weeks have elapsed. Notwithstanding this successive treatment, a 10% to 15% residue of olives remains on the plant. Apart from its relative inefficiency, this method of detaching olives from the tree goes counter to one of the main requirements for making high quality extra virgin olive oil which is the use of the younger, less ripe olives.

Devices are also used extensively to detach the fruit from the plant by beating action. A variety of devices, based on this principle, are being employed with varying degrees of success. The most popular consist of pneumatically, or electrically, powered combs made of light thin rods. These devices are pulled in a comb-like motion through the plant's thin branches, which bear most of the fruit, while imparting oscillatory beating to the fruit, leaves and branches in the immediate vicinity of the comb's teeth. The olives are detached from the tree by the device's combined beating and combing action. Although with this method it is possible to remove almost all the fruit from the plant, a significant amount of small branches and leaves also fall to the ground. In addition such methods are prone to bruising the olives, and unless the olives are processed for producing olive oil very soon after harvesting, they develop an increased level of acidity. If the level of acidity increases above 0.5%, the producer may no longer label the oil "extra virgin".

SUMMARY OF INVENTION

The present invention provides a device for picking fruit comprising a vibratable body securely engagable with a trunk or a branch of a fruit tree for applying controllable frequency vibrations thereto, the body being mounted on carrying means with respect to which the body is independently movable, and the body including drive means for vibrating the body. Since the power output from the vibratable body can be adjustable manually or controllable automatically by means of a sensor placed on the vibratable body, the vibrations applied to the tree are not forced to be of an uncontrollable amplitude or frequency. Moreover, the vibratory body can be prevented from emitting frequencies that couple substantial vibratory energy to the tree roots. The invention is thus more sympathetic to the tree, and does not damage it. Furthermore, the feature of the body being movable independently of the carrying means helps to ensure that the tree is not unduly stressed by the device. By virtue of the various mechanical and electrical features of embodiments of the invention discussed below, the device is quick and effective, and can be controlled with substantially immediate effect.

Preferably, the drive means comprise at least one piston displaceably mounted in a cylinder of the body. The piston/s which provides the vibratory body inertial mass may be hydraulically or electromagnetically operated.

With embodiments of the present invention, removal of leaves is avoided because there is no physical contact therewith and no beating being applied thereto. As a result, the fruit does not suffer bruising. Falling of leaves is also avoided by preventing the vibratory body from emanating frequencies that are likely to cause leaves detachment.

Advantageously, the vibrations can be linear in direction and can be applied to the trunk or branch substantially normally to the longitudinal axis of said trunk or branch. This avoids the application of tangential forces to the tree and consequent damage to the bark. In this connection, the drive means can advantageously be symmetrically arranged with respect to the tree. In one embodiment, two pistons are provided, one on either side of the trunk or branch. The pistons are then to be driven in synchronism to avoid the production of lateral forces or torques about the tree. Alternatively, two or more pistons can be placed radially around the tree trunk and driven sequentially to avoid the production of tangential forces. This drive means has the advantage of coupling the vibratory energy in the optimum direction for maximum transmission through those branches which impart oscillatory motion to the olive - stem.

In another advantageous development of the invention the vibrations applied to the tree can have a controllable time-varying frequency. For instance, the frequency can be swept from an initial sweep frequency to a lower final sweep frequency, or vice versa. Picking efficiency of 95% of the olives on the tree may thereby be achieved. It is also possible to include a modulation component, which can vary with time in the frequency signal. The modulation component can have a low frequency (corresponding to olive-stem resonances) and a low amplitude (to avoid damage to tree and roots) and thereby excellent picking efficiency can be achieved.

To clarify the invention, the background theory is expanded below.

One way to detach efficiently pendulous fruit from the branches of a tree is to apply to the fruit translational and/or bending (shear) forces of a magnitude sufficient to pull or shear off the fruit from the stem. To induce fruit detachment by the application of translational forces, the pendulum-like non linear resonance properties of the fruit-stem can be exploited.

The non-linear oscillatory motion of the olive with the stem attached to a moving support (the tree branch) has been investigated using the Duffing oscillator mathematical model. According to this non-linear model the resonant frequency is a function of the driving force magnitude and its frequency, stem mechanical properties such as elasticity damping and physical dimensions of both stem and olive. Also under certain driving conditions the phase of the moving olive-stem locks to the phase of the applied drive; i.e. the resonant frequency of the olive-stem follows the frequency of the applied drive. This property is very useful because non linear resonance can be maintained over a wide range of magnitudes and frequencies. This is achieved with a modest amount of drive energy and without the need to synchronize the phase of the drive to that of the olive-stem oscillator

Since it is likely that the physical dimensions and mechanical properties of stems and olives in a tree are all different, their resonant frequencies (both linear and non-linear) cover different ranges. Under these conditions it is more appropriate to employ time variant frequency signals such as a frequency sweep to cover a set or sets of resonant frequency ranges, rather than mono or narrow frequency band drives, as used in the prior art. When the trunk or branch is driven with a vibratory force, the frequency range for olive detachment should be limited to the set of resonances of branches with the attached stems and olives. In fact it may not be advisable to use frequencies as low as a few hertz to only cover the olive-stem set of resonances. At these low frequencies the resulting high amplitude motion applied to the tree trunk can displace and damage the tree's micro root system. To overcome this problem, the modulation components mentioned above are included in the drive signal to produce low frequency sidebands of lower magnitude compared to the higher frequency components occupying the sweep frequency band. The resulting complex signal is not deleterious to the root system but still supplies energy to the olive-stem set of resonances.

By way of example there now follows a detailed description of an embodiment of the invention with reference to the accompanying drawings in which

Fig. 1 shows an exemplary construction of the device;

Fig. 2 shows a schematic view of the invention, and

Fig. 3 shows a schematic view of a hydraulic system forming part of the invention.

In Fig. 1 can be seen a vibratable body 1 engaged with the trunk 8 of an olive tree. The body 1 is resiliently attached to carrying means 2 in the form of a Y-shaped bracket 2 by means of springs 3. Thus, the body is decoupled from the hydraulic arm and hence, the tractor. The body 1 more specifically is mounted on top of the bracket 2 and thus the springs 3 are in compression. The springs 3 need to be of sufficient strength to withhold the weight of the body 1, which can have a mass of 450 kg for example. The bracket 2 is disposed at the end of a robotic hydraulic arm as may be provided on a tractor for instance. Along the sides of the body 1 are provided a hydraulic cylinder 4 and a corresponding subsidiary piston 5 (not visible on the rear side) which serve to open and close adjustable arms 6a and 6b in order that the body may be securely held to the trunk 8 for effective transmission of vibrations therebetween. As viewed in Fig. 1, a first arm 6a, which is nearest the viewer, is provided with cushioning means in the form of a black rubber pad for abutment with the bark of the tree. A second arm 6b which is distal from the viewer is not provided with cushioning means. Alternatively, pad could be located on the second arm 6b. In operation, the first arm 6a is rotated by means of the subsidiary piston 5 until the pad comes into contact with the bark. The second arm 6b lags behind the first arm, and after the first arm has come into engagement with the tree, the second arm comes into abutment with the first arm 6a and applies pressure

thereto. It is thereby possible to adjust the pressure applied by arms 6a, 6b very finely, thereby allowing an optimum coupling of the vibratory energy between the body 1 and the tree 8 and avoiding undue stress on the bark. A corresponding pad is fixed to the vibratable body 1 for abutment with the opposite side of the branch. In this way it is provided that there are only two lines of contact between the pads and the tree, and the direction of the applied vibrational forces is parallel to the displacement between the two lines of contact. Thus there are no tangential forces applied to the bark avoiding damage thereto. There is also no need for lateral pads to be provided.

A pair of main pistons 13 are mounted in cylinders 12 and form part of the drive means responsible for vibrating the body 1. These are discussed in more depth below. An electronic control unit and a hydraulic pressure supply in the embodiment shown are mounted on the tractor (not shown) thereby facilitating user control. The hydraulic equipment placed on the rear of the tractor for connection of the hydraulic pump to the tractor's power take-off.

Some of the hardware required to implement the invention is shown schematically in Fig. 2. The vibratable body 1 contains drive means in the form of two hydraulic cylinders 12, each of which contains one of the corresponding main pistons 13. A hydraulic unit 7 discussed in more depth below provides pressurised fluid to a valve 14, more particularly a servo valve, and takes away low pressure fluid. Upper and lower holding plates 15 hold the vibratable body 1 together. The trunk or branch 8 is held against the body by the adjustable arms or clamps, which are not shown here. Vibrations of the body 1 are transmitted to the appropriate trunk or branch, and because the body can move with respect to the carrying means, transmission of the vibrations to the carrying means is inhibited. An electronic control unit 18 sends an electric signal $s(t)$, represented by equation 1 below, to the servo valve 14 mounted on the central part of a manifold 11. This valve alternates the flow of hydraulic fluid, supplied by high and low pressure lines 16 and 17, to either the right side

or the left side of piston/cylinder sealing rings via the ducts A and B respectively. Corresponding ducts are provided but not shown in connection with the second main piston 13, shown in Fig. 2 adjacent to the first main piston 13. The resulting translational motion imparted to the main pistons, relative to the cylinders, is the analog of the servo valve drive signal $s(t)$. Reaction forces from the vibration of the main pistons, as internal masses, cause vibration of the body. In addition the two pistons provide the inertial mass (e.g. 350 kg) required to deliver a force of 30,000 N, which is sufficient to vibrate the tree strongly enough to remove olives.

In order to avoid damage to the tree bark, the vibrations are applied to the tree without tangential forces. This is achieved with the present structure of the device because the forces caused by the vibrations are linear in direction and are applied substantially normally to the longitudinal axis of the trunk or branch. By virtue of the two pistons 13 being controlled by the same valve 14, they remain in phase with each other, and thus do not produce tangential components of vibrational motion. Any form of drive means fulfilling such criteria is contemplated within the invention.

A detailed hydraulic fluid flow schematic diagram is shown in Fig. 3. A hydraulic pump 21, driven from a tractor power supply increases the pressure of the fluid pumped from a tank 31 to 3,000 psi (20.7 MPa). The maximum pressure of the fluid is regulated by check valve 22 and after the fluid has gone through a filter 23 it is fed to the servo valve 14. This valve is controlled by the electronic control unit and as pointed out earlier, its function is to switch the direction of the fluid fed into the cylinders 12. Two nitrogen accumulators 24 are located along the high pressure line to dampen high energy impulses which could irreparably damage the pump or other components in the hydraulic circuit. A hand operated valve 28 B in the open position, bypasses the fluid from the high pressure line to the tank. Valve 28 A leads to a pressure gauge. The valves 28 A and 28 B are only operated during warm up and shut down

operations. Due to the different pressures occurring throughout the hydraulic system, different hoses are used to cope with the stresses caused. The hydraulic pump 21 is connected to a hydraulic fluid reservoir 31 by suction hoses, whereas the hoses connecting the hydraulic pump 21 to the valve 14, via the intermediate components, are high pressure hoses. A high pressure pilot hose connects the hydraulic pump to a solenoid valve 29 which is operable to direct the hydraulic fluid e.g. oil, through a cooler 30 should such be necessary. After it has served its purpose of driving the hydraulic cylinders 26, the hydraulic fluid passes back to the reservoir 31 via a return hose 33.

In alternative embodiments of the invention not shown in the figures, it is envisaged that two or more pistons and cylinders are provided, the pistons being arranged orthogonally to one another. The pistons can further be arranged and driven so as to avoid the production of tangential forces. Such a construction advantageously allows a greater olive picking efficiency, by allowing excitation of the tree in more than one plane. The tree can be likened to a tuning fork whose resonance is greatest when a driving force is applied in the plane defined by the handle and tines of said fork. Obviously, in a tree, this plane is not as exactly defined, but by applying the vibrations to the tree in more than one direction, the resonance can be maximised.

As shown in Fig. 2, the electronic control unit 18 is connected to the hydraulic equipment 7 and the valve 14. The control unit 18 emits a signal represented by equation (1) below which controls the valve 14 and hence the vibrations of the pistons 13.

Equation (1) defining the signal properties can be written as:

$$s(t) = \{\cos[(\omega - \alpha)t + m(t)]\} * g(t) \quad (1)$$

Where

$s(t)$ = signal driving the servo valve

$$\dot{\omega} = 2\pi f_h$$

f_h = initial sweep frequency

α = frequency sweep rate = $2\pi(f_h - f_l)/sl$, $f_h > f_l$ and $(f_h - f_l) \leq \Delta f_d$

f_l = final sweep frequency

sl = sweep length

Δf_d = bandwidth suitable for olive detachment

$m(t)$ = modulation function having a frequency value $\ll f_l$

$*$ = convolution operation

$g(t)$ = band pass filter function with a bandwidth $\sim \Delta f_d$

Equation 1 shows that the signal essentially consists of a linear sweep parameter $\dot{\omega} - \alpha t$, and a modulating function $m(t)$. This modulation function is a low frequency sinusoid which causes the production of side band energy at the low end of the bandwidth Δf_d . This side band energy drives the olive – stem system into resonance but due to its low amplitude does not inflict damage on the tree's micro root system. Lastly, the purpose of the band pass filtering function $g(t)$ is to ensure that the frequency components emitted by the device are within the range of frequencies Δf_d which are suitable for detaching olives. As already pointed out above the emitted signal is band limited at the low frequency end to prevent root damage. The signal is also band limited at the high frequency end to reduce energy loss caused by the tree's spurious resonant modes and to concentrate the available energy within the frequency range for olive detachment. Also, the production of high frequencies is limited to prevent the detachment of leaves from the tree.

In operation, the user controls the robotic arm to guide the device into engagement with the tree. Then, the adjustable arms 6 are closed around the trunk or branch to secure the arrangement. Alternatively, it is also envisaged that the device be equipped with a position sensor which can take the form of a laser positioning device for instance, and means for automatically controlling the position of the body 1, whereby the user simply brings the device into

proximity with a trunk or branch and the automatic control means then guide the body into engagement with the tree in a very short time, avoiding any potentially damaging contact with the bark which might occur before engagement. As with previous techniques, the olives can be gathered by placing a large net on the ground beneath the tree or by a vertical net shaped like an upside down cone with its narrower end secured to the base of the tree trunk. Vibrations as described above are then applied to the tree and the fallen olives collected.

Claims

1. A device for removing fruit from a plant comprising a vibratable body securely engagable with a trunk or a branch of a fruit plant for applying controllable frequency vibrations thereto, the body being mounted on carrying means with respect to which the body is independently movable, and the body including drive means for vibrating the body.
2. A device according to claim 1, wherein the vibrations are linear in direction and are applied to the trunk or branch substantially normally to the longitudinal axis of said trunk or branch.
3. A device according to any one of the preceding claims, wherein the device is mounted on a robotic arm, which can be attached to a tractor, the robotic arm having a position sensor and automatic control means whereby the device can be brought rapidly into engagement with the tree without damaging its bark.
4. A device according to any one of the preceding claims, wherein the body further includes an adjustable arm for embracing the trunk or branch.
5. A device according to any one of the preceding claims, further including control means for controlling the frequency and/or the power of the vibrations.
6. A device according to claim 5, wherein the control means comprise electronic control means.
7. A device according to claim 5 or 6, further comprising a sensor connected to the vibratable body for providing feedback to the control means whereby the frequency and/or the power of the vibrations are automatically controllable.

8. A device according to any one of claims 5 to 7, wherein the control means are manually adjustable.
9. A device according to any one of the preceding claims, wherein the vibrations have a frequency which varies with time.
10. A device according to claim 9, wherein the frequency of the vibrations is swept from an initial sweep frequency to a final sweep frequency.
11. A device according to claim 10, wherein the initial sweep frequency is higher than the final sweep frequency.
12. A device according to claim 10, wherein the initial sweep frequency is lower than the final sweep frequency.
13. A device according to any one of claims 9 to 12, wherein the vibrations include a modulation component which has a much lower frequency than the sweep frequency.
14. A device according to any one of claims 9 to 13, wherein the frequency range is limited by a band pass filter.
15. A device according to any of the preceding claims, wherein frequencies which cause leaf detachment from the tree are substantially omitted from the vibrations.
16. A device according to any one of the preceding claims, wherein the drive means comprise an inertial mass which is displaceably mounted in the vibratable body and which is vibratable by the application thereto of driving force.

17. A device according to claim 16, wherein the inertial mass comprises a piston displaceably mounted in a cylinder of the body.

18. A device according to claim 17, wherein the body has two cylinders and two pistons.

19. A device according to claim 18, wherein the body has more than two pistons and cylinders arranged orthogonal to one another for placement around the trunk or branch and driveable sequentially.

20. A device according to any one of claims 17 to 19, wherein the or each piston is a hydraulic piston, the or each cylinder being connected to a supply of pressurised fluid via a valve for controlling the frequency of the vibrations.

21. A device according to any one of claims 16 to 19 wherein the driving force is an electromagnetic force.

22. A device for picking fruit substantially as herein described with reference to the accompanying drawings.

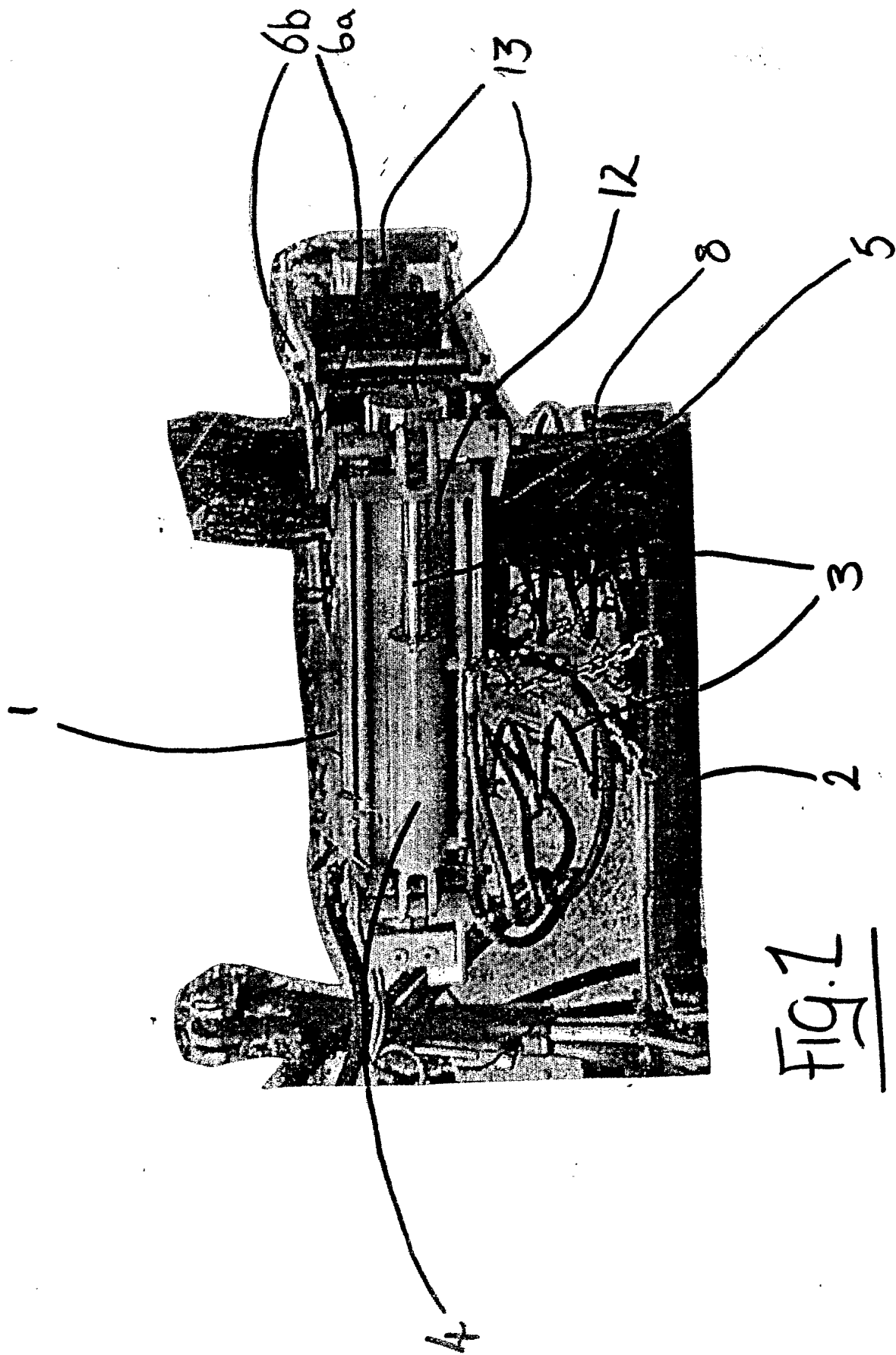


FIG. 1



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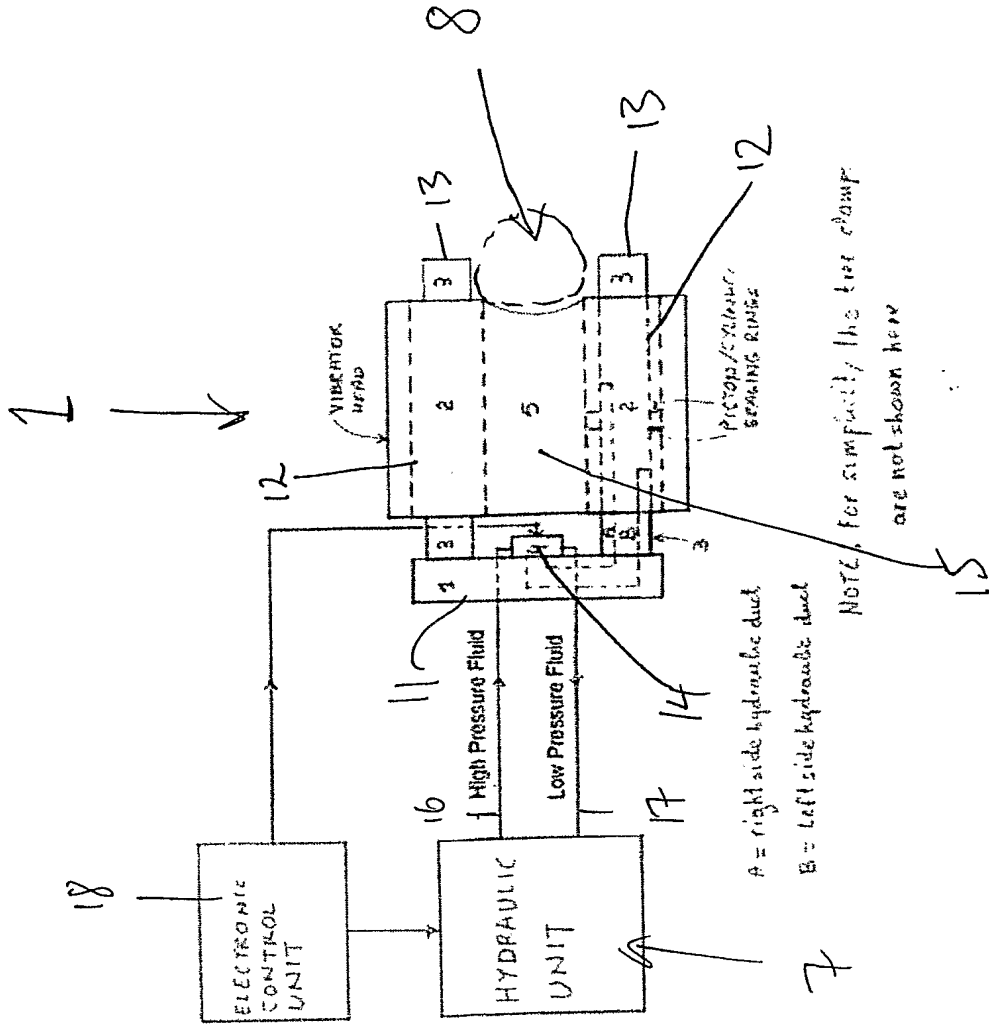


FIG. 2

FLG 3

